SCIENCE

VOL. 88 — FRIDAY, AUGUST 26, 1938 — No. 2278

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. — Garrison, N. Y.

Annual Subscription, $6.00 — Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

VISION IN NATURE AND VISION AIDED BY SCIENCE; SCIENCE AND WARFARE[1]

By The Rt. Hon. LORD RAYLEIGH

PRESIDENT OF THE ASSOCIATION

I. VISION, AND ITS ARTIFICIAL AIDS AND SUBSTITUTES

THE last occasion that the British Association met at Cambridge was in 1904, under the presidency of my revered relative, Lord Balfour, who at the time actually held the position of Prime Minister. That a Prime Minister should find it possible to undertake this additional burden brings home to us how much the pace has quickened in national activities, and I may add, anxieties, between that time and this.

Lord Balfour in his introductory remarks recalled the large share which Cambridge had had in the development of physics from the time of Newton down to that of J. J. Thomson and the scientific school centered in the Cavendish Laboratory, "whose physical speculations," he said, "bid fair to render the closing year of the old century and the opening ones of the new as notable as the greatest which have preceded them." It is a great pleasure to me, as I am sure it is to all of you, that my old master is with us here to-night, as he was on that occasion. I can say in his presence that the lapse of time has not failed to justify Lord Balfour's words. What was then an intelligent anticipation is now a historical fact.

I wish I could proceed on an equally cheerful note. The reputation of the scientific school in the Cavendish Laboratory has been more than sustained in the interval under the leadership of one whose friendly pres-

[1] Address of the President of the British Association for the Advancement of Science, Cambridge, August, 1938.

ence we all miss to-night. The death of Ernest Rutherford leaves a blank which we can never hope to see entirely filled in our day. We know that the whole scientific world joins with us in mourning his loss.

Lord Balfour's address was devoted to topics which had long been of profound interest to him. He was one of the first to compare the world picture drawn by science and the world picture drawn by the crude application of the senses, and he emphasized the contrast between them. A quotation from his address will serve as an appropriate text to introduce the point of view which I wish to develop this evening.

"So far," he said, "as natural science can tell us, every quality or sense or intellect which does not help us to fight, to eat and to bring up our children, is but a by-product of the qualities which do. Our organs of sense perception were not given us for purposes of research . . . either because too direct a vision of physical reality was a hindrance, not a help in the struggle for existence . . . or because with so imperfect a material as living tissue no better result could be attained."

Some of those who learn the results of modern science from a standpoint of general or philosophical interest come away, I believe, with the impression that what the senses tell us about the external world is shown to be altogether misleading. They learn, for example, that the apparent or space-filling quality of the objects called solid or liquid is a delusion and that the volume of space occupied is held to be very small compared with that which remains vacant in between. This is in such violent contrast with what direct observation seems to show that they believe they are asked to give up the general position that what we learn from our senses must be our main guide in studying the nature of things.

Now this is in complete contrast with the standpoint of the experimental philosopher. He knows very well that in his work he does and must trust in the last resort almost entirely to what can be seen and that his knowledge of the external world is based upon it; and I do not think that even the metaphysician claims that we can learn much in any other way. It is true that the conclusions of modern science seem at first sight to be very far removed from what our senses tell us. But on the whole the tendency of progress is to bring the more remote conclusions within the province of direct observation, even when at first sight they appeared to be hopelessly beyond it.

For example, at the time of Lord Balfour's address some who were regarded as leaders of scientific thought still urged that the conception of atoms was not to be taken literally. We now count the atoms by direct methods. We see the electrometer needle give a kick and we say, "There goes an atom." Or we see the path of an individual atom marked out by a cloud track and we see where it was abruptly bent by a violent collision with another atom.

Again, the theory of radioactive decomposition put forward by Rutherford, however cogent it may have seemed and did seem to those who were well acquainted with the evidence, was originally based on indirect inferences about quantities of matter far too small to be weighed on the most delicate balance. Chemists were naturally inclined to feel some reserve; but in due course the theory led to a conclusion which could be tested by methods in which they had confidence—the conclusion, namely, that lead contained in old uranium minerals ought to have a lower atomic weight than ordinary lead and in all probability to be lighter, and on trying this out it proved to be so. More recently we have the discovery of heavy hydrogen with twice the density of ordinary hydrogen and heavy water which is the source of it.

Lastly, the conclusion that ordinary matter is not really space-filling has been illustrated by the discovery that certain stars have a density which is a fabulous multiple of the density of terrestrial matter. Although this is in some sense a deduction as distinguished from an observation, yet the steps required in the deduction are elementary ones entirely within the domain of the older physics.

This and many other points of view have seemed at first sight to contradict the direct indication of our senses. But it was not really so. They were obtained and could only be obtained by sense indications rightly interpreted. As in the passage from Lord Balfour already quoted the senses were not primarily developed for purposes of research, and we have in large measure to adapt them to that purpose by the use of artificial auxiliaries. The result of doing so is often to reveal a world which to the unaided senses seems paradoxical.

I have chosen for the main subject of this address a survey of some of the ways in which such adaptations have been made. I shall naturally try to interest you by dwelling most on aspects of the subject that have some novelty; but apart from these there is much to be gleaned of historical interest, and when tempted I shall not hesitate to digress a little from methods and say something about results.

I shall begin with a glance at the mechanism of the human eye, so far as it is understood. I shall show how the compromise and balance between different competing considerations which is seen in its design can be artificially modified for special purposes. All engineering designs are a matter of compromise. You can not have everything. The unassisted eye has a field of view extending nearly over a hemisphere. It gives an indication very quickly and allows comparatively rapid changes to be followed. It responds best

to the wave-lengths actually most abundant in daylight or moonlight. This combination of qualities is ideal for what we believe to be nature's primary purpose, that is for finding subsistence under primitive conditions and for fighting the battle of life against natural enemies. But by sacrificing some of these qualities, and in particular the large field of view, we can enhance others for purposes of research. We may modify the lens system by artificial additions over a wide range for examining the very distant or the very small. We can supplement and enormously enhance the power of color discrimination which nature has given us. By abandoning the use of the retina and substituting the photographic plate as an artificial retina, we can increase very largely the range of spectrum which can be utilized. This last extension has its special possibilities, particularly in the direction of using waves smaller than ordinary, even down to those which are associated with a moving electron. By using the photoelectric cell as another substitute for the retina with electric wire instead of optic nerve and a recording galvanometer instead of the brain we can make the impressions metrical and can record them on paper. We can count photons and other particulate forms of energy as well. We can explore the structure of atoms, examine the disintegration of radioactive bodies, and trace out the mutual relation of the elements. Indeed, by elaborating this train of thought a little further almost the whole range of observational science could be covered. But within the compass of an hour or so one must not be too ambitious. It is not my purpose to stray very far from what might, by a slight stretch of language, fall under the heading of extending the powers of the eye.

Most people who have a smattering of science now know the comparison of the eye with the camera obscura, or better, with the modern photographic camera—with its lens, iris, diaphragm, focussing adjustment and ground glass screen, the latter corresponding to the retina. The comparison does not go very far, for it does not enter upon how the message is conveyed to the brain and apprehended by the mind; or even upon the minor mystery of how colors are discriminated. Nevertheless, it would be a great mistake to suppose that the knowledge which is embodied in this comparison was easily arrived at. For example, many acute minds in antiquity thought that light originated in the eye rather than in the object viewed. Euclid in his optics perhaps used this as a mathematical fiction practically equivalent to the modern one of reversing the course of a ray, but other authors appealed to the apparent glow of animal eyes by lamplight, which shows that they took the theory quite literally. The Arabian author Alhazen had more correct ideas and he gave an anatomical description of the eye, but apparently regarded what we call the crystalline lens as the light-sensitive organ. Kepler was the first to take the modern view of the eye.

The detailed structure of the retina, and its connection with the optic nerve, has required the highest skill of histologists in interpreting difficult and uncertain indications. The light-sensitive elements are of two kinds, the rods and cones. The rods seem to be the only ones used in night vision, and do not distinguish colors. The cones are most important in the center of the field of view, where vision is most acute, and it seems to be fairly certain that in the foveal region each cone has its own individual nervous communication with the brain. On the other hand, there is not anything like room in the cross-section of the optic nerve to allow us to assign a different nerve fiber to each of the millions of rods. A single fiber probably has to serve 200 of them.

The nervous impulse is believed to travel in the optic nerve as in any other nerve, but what happens to it when it arrives at the brain is a question for the investigators of a future generation.

The use of lenses is one of the greatest scientific discoveries: we do not know who made it. Indeed, the more closely we inquire into this question the vaguer it becomes. Spectacle lenses as we know them are a medieval invention, dating from about A.D. 1280. Whether they originated from some isolated thinker and experimentalist of the type of Roger Bacon, or whether they were developed by the ingenuity of urban craftsmen, can hardly be considered certain. There are several ways in which the suggestion might have arisen, but a glass bulb filled with water is the most likely. Indeed, considering that such bulbs were undoubtedly used as burning glasses in the ancient world, and that the use of them for reading small and difficult lettering is explicitly mentioned by Seneca, it seems rather strange that the next step was not taken in antiquity. Apparently the explanation is that the magnification was attributed to the nature of the water rather than to its shape. At all events, it may readily be verified that a 4- or 5-inch glass flask full of water, though not very convenient to handle, will give a long-sighted newspaper reader the same help that he could get from a monocle.

The invention of lenses was a necessary preliminary to the invention of the telescope, for, as Huygens remarked, it would require a superhuman genius to make the invention theoretically.

The retina of the eye on which the image is to be received has structure. We may compare the picture on the retina to a design embroidered in woolwork, which also has a structure. Clearly such a design can not embody details which are smaller than the mesh of the canvas which is to carry the colored stitches. The

only way to get in more detail is to make the design, or rather such diminished part of it as the canvas can accommodate, on a larger scale. Similarly with the picture on the retina. The individual rods and cones correspond with the individual meshes of the canvas. If we want more detail of an object we must make the picture on the retina larger, with the necessary sacrifice of the field of view. If the object is distant we want for this a lens of longer focus instead of the eye lens. We can not take the eye lens away, but, what amounts to nearly the same thing, we can neutralize it by a concave lens of equal power put right up to it, called the eyepiece. Then we are free to use a long focus lens called the telescopic objective to make a larger picture on the retina. It must of course be put at the proper distance out to make a distinct picture. This is a special case of the Galilean telescope, which lends itself to simple description. It is of no use to make the picture larger if we lose definition in the process. The enlarged image must remain sharp enough to take advantage of the fine structure of the retinal screen that is to receive it. It will not be sharp enough unless we make the lens of greater diameter than the eye. Another reason for using a large lens is to avoid a loss of brightness.

It seems paradoxical that the image of a star should be smaller the larger the telescope. Nevertheless it is a necessary result of the wave character of light. We can not see the true nature of, for example, a double star unless the two images are small enough not to overlap and far enough apart to fall on separated elements of the observer's retina.

When the problem is to examine small objects we look at them as close as we can: here the short-sighted observer has an advantage. By adding a lens in front of the eye lens to increase its power we can produce a kind of artificial short sight and get closer than we could otherwise, so that the picture on the retina is bigger. This is a simple microscope and we can use it to examine the image produced by an objective lens; if this image is larger than the object under examination we call the whole arrangement a compound microscope.

Given perfect construction there is no limit in theory to what a telescope can do in revealing distant worlds. It is only a question of making it large enough. On the other hand, there is a very definite limit to what the microscope used with, say, ordinary daylight can do. It is not that there is any difficulty in making it magnify as much as we like. This can be done, *e.g.*, by making the tube of the microscope longer. The trouble is that beyond a certain point magnification does no good. Many people find this a hard saying, but it must remembered that a large image is not necessarily a good image. We are up against the same difficulty as before. A point on the object is necessarily spread out into a disc in the image, due to the coarseness of structure of light itself as indicated by its wave-length. I can not go into the details, but many of you will know that points on the object which are something less than half a wave-length, or say a one-hundred-thousandth of an inch apart, can not be distinctly separated. This is the theoretical limit for a microscope using ordinary light, and it has been practically reached. The early microscopists would have thought this more than satisfactory; but the limit puts a serious obstacle in the way of biological and medical progress to-day. For example, the pathogenic bacteria in many cases are about this size or less; and there is special interest in considering in what directions we may hope to go further.

Since microscopic resolution depends on having a fine structure in the light itself, something, though not perhaps very much, may be gained by the use of ultra-violet light instead of visible light. It then becomes necessary to work by photography. We are nearing the region of the spectrum where almost everything is opaque. In the visual region nearly every organic structure is transparent and to get contrast stains have to be used which color one part more deeply than the other. In the ultra-violet, on the other hand, we get contrast without staining and, as Mr. J. W. Barnard has shown, the advantage lies as much in this as in the increased resolving power. For example, using the strong ultra-violet line of the mercury vapor lamp, which has about half the wave-length of green light, he finds that a virus contained within a cell shows up as a highly absorptive body in contrast with the less absorptive elements of the cell. So that ultra-violet microscopy offers some hope of progress in connection with this fundamental problem of the nature of viruses.

With ultra-violet microscopy we have gone as far as we can in using short waves with ordinary lenses made of matter, for the available kinds of matter are useless for shorter waves than these, and it might well seem that we have here come to a definite and final end. Yet it is not so. There are two alternatives, which we must consider separately. Paradoxical as it may seem, for certain radiations we can make converging lenses out of empty space; or alternatively we can make optical observations without any lenses at all.

The long-standing controversy which raged in the nineties of the last century as to whether cathode rays consisted of waves or of electrified particles was thought to have been settled in favor of the latter alternative. But scientific controversies, however acutely they may rage for a time, are apt, like industrial disputes, to end in compromise; and it has been so in this instance. According to our present views the cathode rays in one aspect consist of a stream of electrified

particles; in another, they consist of wave trains, the length being variable in inverse relation to the momentum of the particles.

Now cathode rays have the property of being bent by electric or magnetic forces, and far-reaching analogies have been traced between this bending and the refraction of light by solids; indeed, a system of "electron optics" has been elaborated which shows how a beam of cathode rays issuing from a point can be reassembled into an image by passing through a localized electrostatic or magnetic field having axial symmetry. This constitutes what has been called an electrostatic or magnetic lens. It is then possible to form a magnified image of the source of electrons on a fluorescent screen, and that is the simplest application. But we can go further and form an image of an obstructing object such as a fine wire by means of one magnetic lens, acting as objective, and amplify it by means of a second magnetic lens, which is spoken of as the eyepiece, though of course it is only such by analogy, for the eye can not deal directly with cathode rays. The eyepiece projects the image on to a fluorescent screen or photographic plate. So far we have been thinking of the electron stream in its corpuscular aspect. But we must turn to the wave aspect when it comes to consideration of theoretical resolving power. The wave-length associated with an electron stream of moderate velocity is so small that if the electron microscope could be brought to the perfection of the optical microscope, it should be able to resolve the actual atomic structure of crystals. This is very far indeed from being attained, the present electron microscope being much further from its own ideal than were the earliest optical microscopes. Nevertheless, experimental instruments have been constructed which have a resolving power several times better than the modern optical microscope. The difficulty is to apply them to practical biological problems.

It is not to be supposed that the histological technique so skilfully elaborated for ordinary microscopy can at once be transferred to the electron microscope. For example, the relatively thick glass supports and covers ordinarily used are out of the question. Staining with aniline dyes is probably of little use, and the fierce bombardment to which the delicate specimen is necessarily exposed will be no small obstacle. Certain standard methods, however, such as impregnation with osmium, seem to be applicable: and there is some possibility that eventually the obscure region between the smallest organisms and the largest crystalline structure may be explored by electron microscopy.

In referring to the limitations on the use of lenses I mentioned the other alternative that we might, in order to work with the shortest waves, dispense with lenses altogether: and in fact in using x-rays this is done. We are then limited to controlling the course of the rays by means of tubes or pinholes. This restriction is so serious that it altogether defeats the possibility of constructing a useful x-ray microscope analogous to the optical or the electron microscope. In spite of this the use of x-rays is of fundamental value for dealing with a particular class of objects, namely, crystals, which themselves have a regular spacing, comparable in size with the length of the waves. Just as the spacing of a ruled grating (say one 1/20,000th of an inch) can be compared with the wave-length of light by measuring the angle of diffraction, so the spacing of atoms in a crystal can be compared with the wave-length of x-rays. But here the indications are less direct than with the microscope, and depend on the object having a periodic structure. So that the method hardly falls within the scope of this address. How essential the difference is will appear if we consider that the angle to be observed becomes greater and not less the closer the spacing of the object under test.

Color vision is one of nature's most wonderful achievements, though custom often prevents our perceiving the wonder of it. We take it for granted that any one should readily distinguish the berries on a holly bush, and we are inclined to be derisive of a color-blind person who can not do so. But so far anatomy has told us little or nothing of how the marvel is achieved. Experiments on color vision show that three separate and fundamental color sensations exist. It is probable that the cones of the retina are responsible for color vision and the rods for dark adapted vision which does not discriminate color. But no division of the cones into three separate kinds corresponding to the three color sensations has ever been observed. Nor is any anatomical peculiarity known which allows a color-blind eyes to be distinguished from a normal one.

Can artificial resources help to improve color discrimination? In some interesting cases they can. Indeed, the whole subject of spectroscopy may be thought of as coming under this head. We can recognize the color imparted by sodium to a flame without artificial help. When potassium is present as well, the red color due to it can only be seen when we use a prism to separate the red image of the flame from the yellow one. Such a method has its limitations, because if the colored images are more numerous they overlap, and the desired separation is lost. To avoid this it is necessary to make a sacrifice, and to limit the effective breadth of the flame by a more or less narrow slit. And if the images are very numerous the slit has to be so narrow that all indication of the breadth of the source is lost. This, of course, is substantially the method of spectroscopy, into which I do not enter

further. But there is an interesting class of cases where we can not afford to sacrifice the form of the object entirely to color discrimination. Consider, for example, the prominences of the sun's limb, which are so well seen against the darkened sky of an eclipse, but are altogether lost in the glare of the sky at other times. In order to see them prismatic dispersion is made use of, and separates the monochromatic red light of hydrogen from the sky background. A slit must be used to cut off the latter: but if it is too narrow the outlines of the prominence can not be seen. By using a compromise width it is possible to reconcile the competing requirements in this comparatively easy case. Indeed, M. B. Lyot, working in the clear air of the observatory of the Pic du Midi, where there is less false light to deal with, has even been able to observe the prominences through a suitable red filter, which enables the whole circumference of the sun to be examined at once, without the limitations introduced by a slit. A much more difficult problem is to look for bright hydrogen eruptions projected on the sun's disc, and at first sight this might well seem hopeless. A complete view of them was first obtained by photography, but I shall limit myself to some notice of the visual instrument perfected by Hale and called by him the spectrohelioscope. A very narrow slit has to be used, and hence only a very small breadth of the sun's surface can be seen at any one instant. But the difficulty is turned by very rapidly exposing to view successive strips of the sun's surface side by side. The images then blend, owing to persistence of vision, and a reasonably broad region is included in what is practically a single view. I must pass over the details of mechanism by which this is carried out.

There are now a number of spectrohelioscopes over different parts of the world, and a continuous watch is kept for bright eruptions of the red hydrogen lines. Already these are found to be simultaneous with the "fading" of short radio waves over the illuminated hemisphere of the earth, and the brightest eruptions are simultaneous with disturbances of terrestrial magnetism. At the Mount Wilson Observatory such eruptions have been seen at the same time at widely separated points on the sun, indicating a deep-seated cause. There are therefore very interesting and fundamental questions within the realm of this method of investigation.

We have so far been mainly considering how we may adapt our vision for objects too small or too far off for unassisted sight, and for color differences not ordinarily perceptible. This is chiefly done by supplementing the lens system of the eye by additional lenses or by prisms. We can not supplement the retina, but in certain cases we can do better. We can substitute an artificial sensitive surface which may be either photographic or photoelectric.

That certain pigments are bleached by light is an observation that must have obtruded itself from very early time—indeed, it is one of the chief practical problems of dyeing to select pigments which do not fade rapidly. If a part of the colored surface is protected by an opaque object—say a picture or a mirror hanging over a colored wallpaper—we get a silhouette of the protecting object, which is in essence a photograph.

Again, it is a matter of common observation that the human skin is darkened by the prolonged action of the sun's light, and here similarly we may get what is really a silhouette photograph of a locket, or the like, which protects the skin locally. In this case we are perhaps retracing the paths which nature herself has taken: for the evolution of the eye is regarded as having begun with the general sensitiveness to light of the whole surface of the organism.

The sensitivity of at all events the dark adapted eye depends on the accumulation on the retinal rods of the pigment called the visual purple, of which the most striking characteristic is its ready bleaching by light. We can even partially "fix" the picture produced in this way on the retina of, for example, a frog by means of alum solution. This brings home to us how clearly akin are the processes in the retina to those in the photographic plate, even though the complexity of the former has hitherto largely baffled investigation.

There are then many indications in nature of substances sensitive to light, and quite a considerable variety of them have from time to time been used in practical photographic processes. But compounds of silver, which formed the basis of the earliest processes, have maintained the lead over all others. The history of photography by means of silver salts can not be considered a good example of the triumph of the rational over the empirical. For instance, the discovery of developers came about thus. The first workers, Wedgewood and Davy (1802), had found that they got greater sensitivity by spreading the silver salt on white leather instead of paper. An early experimenter, the Reverend J. B. Reade (1837), was anxious to repeat this experiment, and sacrificed a pair of white kid gloves belonging to his wife for the purpose. When he wished to sacrifice a second pair, the lady raised a not unnatural objection, and he said, 'Then I will tan paper.' He treated paper with an infusion of oak galls and found that this increased the sensitivity greatly. It amounted to what we should call exposing and developing simultaneously. But, in using the method, it is easily observed that darkening continues after exposure is over, and this leads to beginning development after the exposure. This step was taken by Fox Talbot a year or two afterwards. Instead of crude infusion of galls he used gallic acid. Later pyrogallic acid was used instead of gallic acid, and still survives.

The use of gelatine as a medium to contain the silver halide was a more obvious idea. But it was not so easy to foresee that the sensitivity of silver salts would be much further increased when they were held in this medium. For long this remained unexplained, until it was noticed that some specimens of gelatine were much more active than others. This was ultimately traced by S. E. Sheppard to the presence of traces of mustard oil, a sulfur compound, in the more active specimens. This, in turn, depends in all probability on the pasturage on which the animals that afford the gelatine have been fed. The quantity present is incredibly small, comparable in quantity with the radium in pitchblende.

(To be concluded)

SCIENTIFIC EVENTS

AGRICULTURAL RESEARCH AT ROTHAMSTED

LORD FEVERSHAM, parliamentary secretary to the British Minister of Agriculture, announced recently that the Rothamsted Experimental Station at Harpenden, the oldest agricultural research institution in the world, had been granted £14,500 by the British government to meet half the cost of building extensions. The station hopes to celebrate its centenary in 1943 with a comprehensive building scheme.

According to the London *Times,* the investigations in progress at the experimental field plots and laboratories include research into the "take-all" infective disease, found in all places where there is an alkali light soil, which attacks wheat. In other parts of the world it is a serious disease, and Australia can lose 80 to 90 per cent. of a crop. With the development of mechanized farming the disease has appeared in Great Britain. The fungus persists in the soil, but it has been found that ground rye meal will halve its persistence.

The Department of Entomology is studying the migration of insects and their relation to climatic conditions. Ingenious traps have been arranged, some like glass lobster pots, which have been out in the fields for four years. The catch one night was 70,000 insects. With the data collected the station can get a measure of the total abundance of insects and so issue forecasts. Some of the experimental field plots have been under surveillance for 100 years.

At a luncheon given by the Lawes Agricultural Trust Committee, Lord Radnor, who presided, referred to the importance of Rothamsted. Since 1919 the loss of agricultural land was very nearly 20,000,000 acres, and while only 20 per cent. of this was due to town expansion, there was a considerable area of rough grazing and unproductive land. Many countries, on which Great Britain relied, were finding that the stored fertility of the land was coming to an end and that they would have to find other methods of agricultural production to maintain fertility.

RESEARCH LABORATORIES AUTHORIZED BY THE AGRICULTURAL ADJUSTMENT ACT

SECRETARY WALLACE has announced that research laboratories authorized by the Agricultural Adjustment Act of 1938 will be established in four major farm-producing areas. He also named the surplus farm commodities on which the work will be done during the initial program. Section 202 of the Agricultural Adjustment Act of 1938 instructs the Secretary of Agriculture to establish four regional research laboratories for research on new uses and market outlets for agricultural products. According to the law, funds available for the laboratories and their work must be divided equally among the four.

The areas are to be known as the Southern, Eastern, Northern and Western major farm producing areas. The states included in these areas are:

Southern Area: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Oklahoma, South Carolina and Texas.

Eastern Area: Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia and West Virginia.

Northern Area: Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Michigan.

Western Area: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming.

In deciding on this grouping of states the distribution and type of agriculture production, farm population, farm income, value of farm property, total population and other facts were taken into account. Secretary Wallace pointed out that it is of first importance that the research load among the four laboratories should be equalized and coordinated for the efficient performance of the task specified by the Congress. This is especially necessary because the total funds available for these laboratories, $4,000,000, must be equally divided among them. He stated that the department had given full consideration to questions bearing on regional interest and unity in each area. They had realized from the beginning that the four major farm producing areas must be so defined and the work so organized that it would be possible ultimately to include in the program, so far as resources permitted, the major surplus commodities of interest to any area. The central idea throughout had been to secure results efficiently. These results

would know no boundaries of state or area, but would benefit agriculture throughout the country."

Work in the initial stages of the program will be concentrated on the following farm commodities and their by-products: In the southern laboratory, cotton, sweet potatoes and peanuts; in the eastern laboratory, tobacco, apples, Irish potatoes, milk products and vegetables; in the northern laboratory, corn, wheat and agricultural waste products; in the western laboratory, fruits (other than apples) and vegetables, Irish potatoes, wheat and alfalfa.

Secretary Wallace is planning for a conference within the next two months in each of the areas to consult with research institutions and representatives of producers and of industries.

SYLVATIC PLAGUE LABORATORY OF THE UNIVERSITY OF CALIFORNIA

THE University of California proposes to establish in connection with the Medical School in San Francisco a sylvatic plague laboratory to control sylvatic plague, which is now wide-spread in the rodent population of the western states. The plague, according to observations and studies thus far made, appears, however, to lack the virulence of other contagions, such as bubonic plague, that have appeared in the West in the past.

The establishment of the laboratory has been made possible by a gift of $24,000 from the Rosenberg Foundation of San Francisco. Of this amount $14,000 is to be used for the construction of a building and the balance for research and personnel. It is expected that the building will be ready by October 1. It will include a two-story section 12 feet wide by 36 feet long, and a one-story section 10 feet wide by 18½ feet long. The laboratory will be staffed and administered by the Hooper Foundation. The work of the laboratory will be concentrated on the rodent fleas, the principal carriers. Both the state and the university have been active in the campaign against sylvatic plague for some years past. All interested agencies have formed a Sylvatic Plague Committee, which has devoted itself to the collection of evidence of this plague everywhere on the American Continent and is taking measures to combat it. Anti-plague serum is being kept constantly on hand at the Hooper Foundation.

Four non-fatal human cases of the plague have been bacteriologically proved thus far, and there is said to be strong evidence that a fifth case was infected with the plague bacillus. The plague has taken a considerable toll among the rodent populations of the state, the infected fleas being found on squirrels, chipmunks, chickarees and other forms. The Hooper Foundation has counted thirteen rodents and rodent varieties that suffer from spontaneous plague, the list including squirrels, marmots, chipmunks, prairie dogs, mice and rats.

It is generally believed that the West Coast became infected in the course of the pandemic of 1894, which originated in Hongkong. It is assumed that rats conveyed the seed to the shores of California and spread it to the squirrels. It has now reached Montana and appears to be working eastward.

THE SQUIBB INSTITUTION FOR MEDICAL RESEARCH

E. R. SQUIBB AND SONS have announced the establishment of the Squibb Institution for Medical Research, for which a laboratory building in New Brunswick, N. J., has been erected at a cost of $750,000. It is planned to dedicate the laboratory in October. It is stated in the official announcement that research activity, already underway, has been organized in four main divisions—experimental medicine, pharmacology, bacteriology and virus diseases, and organic chemistry. In addition, the institute will conduct a biochemical laboratory and a medicinal chemistry laboratory.

To provide clinical facilities for the research staff, a plan of hospital affiliation is being worked out by the Division of Experimental Medicine. A free ward of fifteen or twenty beds will be maintained for the observation of patients in connection with various problems being studied at the institute.

Dr. Geo. A. Harrop, since last year director of research at New Brunswick, who was previously associate professor of medicine at the Johns Hopkins University and associate physician of the Johns Hopkins Hospital, has been appointed director of research in charge of the institute. Dr. Harrop will also be at the head of the Division of Experimental Medicine.

Other appointments are:

Dr. Harry B. van Dyke, professor and head of the department of pharmacology of the Peiping Union Medical College in China, has been made head of the Division of Pharmacology. He was formerly associate professor of pharmacology at the University of Chicago.

Dr. Geoffrey W. Rake, chief of the Division of Bacteriology, formerly research associate in the Connaught Laboratories of the University of Toronto, has been placed at the head of the Division of Bacteriology and Virus Diseases. Dr. Rake was previously an associate in the Rockefeller Institute for Medical Research.

The head of the Division of Organic Chemistry will be Dr. Erhard Fernholz, formerly of the University of Göttingen and Princeton University, and more recently with the research laboratory of Merck and Company.

Dr. Hans Jensen will be associate in charge of the biochemical laboratory. He was formerly associate in pharmacology at the Johns Hopkins University, where he cooperated with the late Professor John Jacob Abel, since 1932 in the laboratory for endocrine research.

William A. Lott, now of the research laboratory of E.

R. Squibb and Sons, formerly instructor in chemistry at Rutgers University, will be associate in charge of the Medicinal Chemistry Laboratory.

THE SEMI-CENTENNIAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA

The semi-centennial meeting of the Geological Society of America will be held at the Waldorf Astoria Hotel, New York City, on December 28, 29 and 30.

According to the preliminary program, Dr. Arthur L. Day, the retiring president, will deliver his address on Thursday evening. This will be followed by a complimentary smoker. On Friday there will be given a special anniversary day program by leading representatives in several major fields of geology.

With this year, the Geological Society of America will complete a fifty-year period of service in geologic science. It was formally organized at Ithaca, New York, in December, 1888, on call of a Special Committee on Organization, composed of Alexander Winchell (chairman), John J. Stevenson (secretary), Charles H. Hitchcock, John R. Procter and Edward Orton. The first meeting, held in conjunction with the American Association for the Advancement of Science, Section E, was attended by thirteen men, only one of whom, Professor Herman LeRoy Fairchild, of Rochester, is still living. This first meeting was called with a pledged membership of 112 men, who became known thereafter as original fellows. The first election resulted in the addition of 14 fellows. Out of this total number, 6 original fellows and 1 elected fellow are still living.

Now, after fifty years, the society has a membership of 700, all but a handful of whom have come into the organization since those early days; and it has seemed appropriate, therefore, to pause at the end of a period which has seen remarkable development in many ways and take stock of accomplishment and responsibilities. To this end, special observance is planned at the annual meeting of 1938.

The quarter-centennial of the society was observed in Princeton in December, 1913. A part of the opening session of the annual meeting of that year was devoted to a symposium on the work of the society, and opportunity was made at the annual dinner for the story of the initiation of the society. The membership at that time was 380. One hundred and thirty fellows attended the quarter-centennial meeting, the total registration being 265.

The Geological Society, as has long been the custom, invites the Paleontological Society and the Mineralogical Society of America to hold annual meetings also at this time and take part in other activities. The Society of Economic Geologists will be represented and will hold a luncheon. The Seismological Society of America also has been invited to hold scientific sessions at this time. Special meetings are also being arranged for the Section of Vertebrate Paleontologists.

In connection with the meeting the following excursions are planned:

Excursion 1. Glacial and Tertiary Geology, Staten Island and New Jersey. Leader, Dr. Meredith Johnson.

Excursion 2. Engineering Geology in the Vicinity of New York. Leaders, Dr. Charles P. Berkey, James F. Sanborn and Thomas Fluhr.

Excursion 3. Geology of the Palisades. Leader, Dr. S. James Shand.

Excursion 4. Airplane Trip over Manhattan Island and Vicinity. Leader, Dr. Girard Wheeler.

RECENT DEATHS

Guy N. Collins, principal botanist in charge of the Division of Genetics and Biophysics of the Bureau of Plant Industry of the U. S. Department of Agriculture, died on August 14 at the age of sixty-six years.

Dr. Abram T. Kerr, professor of anatomy at Cornell University, died on August 15 at the age of sixty-five years. He had been connected with the university since 1900.

Dr. Edwin Beer, who retired last March as chief of the urological service at Mt. Sinai Hospital, New York City, died on August 13 at the age of sixty-two years.

Dr. G. M. Johnstone MacKay, director of research at the Stamford, Conn., laboratories of the American Cyanamid Company, died on July 29 at the age of fifty-five years.

Dr. Jan Constantijn Costerus, formerly director of the Technical School at Amsterdam, died on July 31 at the age of eighty-nine years. Dr. Costerus is known for the long series of articles he published on plant-teratology, in part with Dr. J. J. Smith.

The death at the age of sixty-five years is announced of Dr. Leo Frobenius, director of the Institute for the Study of Morphology of Civilization in Frankfort-on-Main. Dr. Frobenius led twelve expeditions to Africa. The Frobenius collection at the institute comprises more than 3,500 facsimiles of prehistoric rock paintings and engravings. Dr. Frobenius visited New York last year to attend the opening of an exhibition at the Museum of Modern Art of 200 prehistoric cave drawings from his collection.

Nature records the death on June 19 of the Rev. Dr. W. C. Willoughby, of Birmingham, an authority on the Bantu of South Africa, at the age of eighty-one years, and of Captain F. S. Barnwell, chief designer of the Bristol Aeroplane Company, a pioneer in British aviation, on August 2, aged fifty-eight years.

SCIENTIFIC NOTES AND NEWS

IT is noted in *Nature* that honorary foreign members of the Royal Society of Edinburgh have been elected as follows: Dr. Henry Norris Russell, chairman of the department of astronomy and director of the Observatory, Princeton University; Dr. F. Enriques, professor of mathematics, Royal University, Rome; and Dr. Karl Freiherr von Tubeuf, professor of botany, University of Munich.

A PORTRAIT of Sir D'Arcy Thompson, of St. Andrews University, president of the Royal Society of Edinburgh, was presented to the society at a recent meeting. The portrait was painted by David S. Ewart and the presentation was made by Professor F. A. E. Crew, director of the Institute of Animal Genetics at the University of Edinburgh.

THE Jenner Medal of the Royal Society of Medicine, London, was presented to Sir Arthur Newsholme, late principal medical officer of the London Local Government Board, at a general meeting of the fellows of the society on July 19. The medal is awarded "for distinguished work in epidemiological research or for pre-eminence in the prevention and control of epidemic disease."

DR. ALEXANDER KÖNIG, professor of ornithology at Bonn, has been awarded the shield of nobility of the German Reich, and Dr. Gottlob Linck, professor of mineralogy and geology at Jena, has received the Goethe Medal for art and science.

M. L'ABBÉ HENRI BREUIL, professor of prehistoric ethnography at the Institute of Human Paleontology, Paris, and of prehistory at the Collège de France, has been elected a member of the Académie des Inscriptions et Belles Lettres, in recognition of his work in prehistory and more especially of his studies of the art of the paleolithic age.

DR. PAUL R. BURKHOLDER, associate professor of botany at Connecticut College, has been appointed associate professor at the University of Missouri.

CASPAR G. BURN, assistant professor in pathology at the Yale Medical School, has been appointed associate professor of pathology at the Long Island College of Medicine. He will be in charge of the pathological service recently established at the Kings County Hospital. John Musser Pearce, formerly of the Rockefeller Institute for Medical Research at Princeton, N. J., has been appointed instructor in pathology.

THE following changes have been made in the faculty of chemistry of the Ohio State University: Associate Professors H. L. Johnston and H. V. Moyer have been promoted to professorships; Assistant Professor L. L. Quill to an associate professorship, and P. M. Harris, instructor, to an assistant professorship. Dr. George Eugene MacWood, National Research Council fellow, 1937–1938, has become an instructor. He takes the place of Dr. John Howe, who has resigned.

RECENT promotions at the Michigan College of Mining and Technology include: From associate professor to professor, Dr. R. M. Dickey, head of the department of geology; from assistant professor to associate professor, in forestry, U. J. Noblet; in mathematics, C. G. Stipe and Dr. J. H. Service; from instructor to assistant professor, in mechanical engineering, H. W. Hawn; in chemistry, Dr. R. F. Makens; in electrical engineering, W. O. Ray; in mathematics and physics, T. C. Sermon.

DR. M. F. ASHLEY-MONTAGU, assistant professor of anatomy at New York University, has been appointed associate professor of anatomy in the Hahnemann Medical College, Philadelphia.

DR. ROBERT DOUGLAS LOCKHART, professor of anatomy in the University of Birmingham, has been appointed Regius professor of anatomy in the University of Aberdeen, in the place of Professor A. Low, who recently retired.

DR. F. A. PANETH has been appointed to the university readership in atomic chemistry tenable at the Imperial College—Royal College of Science, University of London. Since 1933 he has been a consultant of Imperial Chemical Industries and has been engaged in research work with postgraduate students at the Imperial College.

DR. A. A. DUNLAP, assistant mycologist and plant physiologist at the Connecticut Agricultural Experiment Station, has taken up his work as chief of the division of plant pathology and physiology at the Texas Agricultural Experiment Station, College Station. He succeeds the late Dr. J. J. Taubenhaus.

DR. RICHARD S. SHUTT, of the American Cyanamid and Chemical Company, has become supervisor of chemical research at the Battelle Memorial Institute, Columbus, Ohio.

CIVIL members of the National Advisory Committee on Aeronautics appointed by President Roosevelt include Clinton M. Hester, administrator of the newly established Civil Aeronautics Authority, and Dr. Vannevar Bush, president-elect of the Carnegie Institution of Washington. Reappointments include: Dr. Joseph Sweetman Ames, formerly president of the Johns Hopkins University; Edward P. Warner, consulting engineer, formerly professor of aeronautic engineering at the Massachusetts Institute of Technology; Professor Jerome C. Hunsaker, head of the department of me-

chanical engineering at the Massachusetts Institute; Orville Wright and Charles A. Lindbergh.

Dr. Charles Weiss, director of the Research Laboratories of the Mount Zion Hospital, San Francisco, has received a grant from the Committee on Medical Research of the National Tuberculosis Association to be used for a study of the nature of the lysis of tubercle bacilli in cellular exudates. Dr. Weiss will be assisted by Dr. A. Kaplan, formerly of the department of physiology of the University of California.

Dr. Carl L. A. Schmidt, dean of the College of Pharmacy and acting dean of the University of California Medical School, has been named a member of the Committee on the Chemistry of Proteins of the National Research Council.

Thomas J. Duffield, registrar of records and director of the Bureau of Vital Statistics of the Department of Health of New York City, has been appointed an additional American delegate to the forthcoming meeting of the International Commission for the Decennial Revision of the International Nomenclature of Diseases. The meeting opens at Paris on October 3.

Dr. D. H. Lehmer, assistant professor of mathematics at Lehigh University, who was recently awarded a Guggenheim fellowship, will work at various English universities on the analytic theory of numbers.

Dr. C. E. Ford, demonstrator in botany, King's College, University of London, has been appointed geneticist to the Government Rubber Research Scheme, Ceylon.

An investigation of the botanical features of the Chihuahuan Desert is being inaugurated through cooperation of the Desert Laboratory of the Carnegie Institution of Washington and the Arnold Arboretum of Harvard University. The area to be covered includes parts of Texas, New Mexico, Chihuahua, Coahuila, Durango, Zacatecas and San Luis Potosi. Work on the vegetation will be conducted by Dr. Forrest Shreve and Dr. T. D. Mallery, of the Desert Laboratory, and the flora will be investigated by Dr. I. M. Johnston, of Arnold Arboretum. Field work is being conducted during August and September in Coahuila and San Luis Potosi.

Dr. Göte Turesson, director of the Institute of Plant Systematics and Genetics at the Agricultural College of Sweden, at Uppsala, is making an extended journey in North America this summer. His objective is to collect suitable ecotypes of forest trees for the Swedish Forest Tree Breeding Institution, which has been started at Svalöv, South Sweden. He is assisted by C. G. Alm, curator of the old Linnean Botanical Garden and assistant curator of the Uppsala Botanical Museum. The party is doing field work from the Atlantic to the Pacific both in the United States and in Canada, giving special attention to the forests of British Columbia. Dr. Turesson arrived in May and expects to stay until the latter part of October. His address is Harvard Forest, Petersham, Mass.

Dr. Donnel F. Hewitt, principal geologist in charge of the section of metalliferous deposits of the U. S. Geological Survey, left Washington on August 7 to visit geologic field parties in several western states. He planned also to confer with state and survey officials in regard to projects recently set up under the allotment of funds to the survey by the Public Works Administration. Carl G. Paulsen, chief of the Surface Water Division, returned to Washington on August 8, after visiting several district offices in the West. In California plans were made which will tend to expedite the work related to the investigations and the report on the floods being made by the district office of the survey in California.

The London *Times* states that J. Hanbury-Tracy has left on a two-year expedition to the Andes of Venezuela. He and Mrs. Tracy will make a collection of plants for the Royal Botanic Gardens, Kew, and a collection of insects for the British Museum of Natural History. Seeds will also be collected for private collectors, and a series of observations will be taken on behalf of the Royal Meteorological Society. The highest point in the Venezuelan Andes rises to over 16,000 feet and the expedition will conduct operations from camps at between 10,000 and 12,000 feet.

Dr. Juan Negrin, premier of Spain, professor of human physiology at the University of Madrid and director of the physiological laboratory of the Ramon y Cajal Institute, was at Zurich as a Spanish delegate to the International Physiological Congress. Dr. Negrin is reported, in an Associated Press dispatch, to have said: "I was particularly anxious not to miss this congress. I wanted to show that outside of all considerations science maintains its rights and does not cease to impose its duties."

The twenty-third annual meeting of the Optical Society of America will be held on October 27, 28 and 29 at the General Brock Hotel, Niagara Falls, Canada. In addition to the usual program of papers the meeting will include a symposium on the "Optics of Illumination," in which it is planned to include invited papers on terminology and standards, basic principles of illumination, widely used light sources and recent developments in light sources; a popular lecture by Robert McMath, director of the McMath-Hulbert Observatory of the University of Michigan, illustrated with astronomical motion pictures, includ-

ing spectroheliographs of solar prominences; visits to the University of Buffalo, the Spencer Lens Company, the Cyanamid Plant, the Queenstown Power House, the Whirlpool, the Welland Ship Canal and the Locks at Thorold. The meeting will be open to non-members as well as members of the society. Non-members, who desire to receive the advance program, final notices or other information in regard to the meeting, should address their requests to the secretary not later than October 10.

DISCUSSION

AN ALGONKIAN JELLYFISH FROM THE GRAND CANYON OF THE COLORADO

DURING the field study of the Algonkian formations in the Grand Canyon of the Colorado River, one of my field assistants, Mr. C. E. Van Gundy, then a graduate student at the University of California, discovered a well-preserved imprint of a jellyfish in the red sandstones above the great lava sequence which forms the top of the Unkar (lower) division of the Algonkian Grand Canyon series. The jellyfish is above 18 centimeters in major diameter. The specimen was submitted to Dr. R. S. Bassler, of the United States National Museum, who identified it. Later a detailed description will be published. The specimen was exhibited at the annual meeting of the Carnegie Institution in Washington in December, 1937, and will be deposited permanently in the National Museum.

Our studies indicate that the Grand Canyon region was under ocean water at least during a part of early Algonkian (Unkar) time when the lower limestones and some of the clastic sediments were laid down. Toward the close of this epoch, emergence took place, and, upon a land surface which probably stood close to sea level, fluvial sediments were deposited as broad flood plains. The latest event of the Unkar was the opening of fissures, the intrusion of diabasic dikes and sills, and the eruption of about a thousand feet of basalt flows. At the top of the lavas is an erosion surface, which sank below sea level and was buried beneath about 400 feet of red sands and clays; between two of the sand layers, the jellyfish was buried. This sequence has a disconformity above and below, and consequently has been set apart as a new group of Van Gundy[1]; to it the name Nankoweap has been applied. After deposition of these strata, elevation above sea level again occurred, and erosion developed a very even surface plain. Later depression below sea level for a long period was marked by deposition of the Upper Algonkian (Chuar) beds, more than 5,000 feet thick. Algonkian history in the Grand Canyon region was closed by folding and faulting, which built the Grand Canyon Mountains. Erosion accompanying and following this orogeny evolved the Ep-Algonkian peneplain, which remained above the ocean until late Lower or early Middle Cambrian time. During this erosion interval, great volumes of Algonkian strata were removed and, over considerable areas, the whole thickness of more than 12,000 feet was swept away, and the Archean basement below suffered some denudation.

The jellyfish is the only authenticated animal fossil which has been found in the Grand Canyon Algonkian. Walcott[2] in 1886 reported the finding of certain fossils "midway of the lower portion of the shales and limestones" of the Chuar group—"a minute Discinoid or Patelloid shell, a small, Lingula-like shell, a species of Hyolithes, and a fragment of what appears to have been the pleural lobe of the segment of a trilobite belonging to a genus allied to the genera Olenellus, Olenoides or Paradoxides. There is also an obscure Stromatopora-like form that may or may not be organic." In 1899, Walcott[3] described and figured these forms. The discinoid shell was named *Chuaria circularis,* nov. g., and sp. The obscure remnant of a brachiopod shell resembles the Cambrian genus Acrothele. The identification of the Hyolithes was questioned, since the specimen possibly may be an inorganic marking. Doubt also was expressed regarding the identification of the trilobite fragment. The Stromatopora-like form was submitted to Sir William Dawson, who was not certain of its organic origin; none the less he gave it the name "Cryptozooan"! occidentale. I have not examined the specimens figured by Walcott, but the illustrations strongly suggest the multitude of inorganic markings to be found throughout the Grand Canyon series. Re-examination of these specimens must be made to prove their organic origin; certainly the existing descriptions do not prove it. My assistants and I have carefully searched the various zones in this great sequence without making other finds. This scantiness of fossils has long been known and is in keeping with that characteristic of Algonkian beds elsewhere in the world. The explanation of this of course has been debated by geologists and paleontologists. Some have accepted Walcott's opinion that the continents stood above sea level during the great length

[1] C. E. Van Gundy, *Proceedings Geol. Soc. America,* 1936, p. 304, 1937.

[2] C. D. Walcott, Second contribution to the studies of the Cambrian of North America, *U. S. Geol. Surv. Bull.,* 30, p. 43, 1886.

[3] C. D. Walcott, *Bull. Geol. Soc. America,* 10: 232–235, 1899.

of Algonkian time and that the sediments were accumulated in fresh-water lakes of huge size situated at a considerable distance from the margins of the continents. In these lakes was relatively little animal life. This view is not in accordance with the testimony of the sediments, for Barrell[4] has shown that many horizons of the Belt series of northern United States and southern Canada and of the Grand Canyon series strongly indicate deposition below sea level. My detailed studies at the Grand Canyon and some acquaintance with the Belt series, the Apache group of southern Arizona and the unnamed Algonkian series of southeastern California support Barrell's findings. The hypothesis originally advanced by Brooks[5] and recently modified and expanded by Raymond[6] seems a much more reasonable explanation of the paucity of fossils. These authorities and others hold that animals developed a lime- or silica-secreting mechanism for the generation of resistant parts relatively late in their evolution and that this had not taken place in most forms by Algonkian time. Even in the early and middle Cambrian, the secretions were mostly of chitin, but by the late Cambrian many forms developed structures of calcium carbonate and silica. Raymond holds that most pre-Cambrian animals were motile, swimming or crawling forms, lacking in hard parts. Predaceous carnivores apparently were scarce, hence, "the swimming and floating organisms must have increased rapidly until there came a time when the upper, sunlit part of the oceans was over-populated. This would force some individuals to the bottom. . . . Those animals which reached the bottom near the shore, where the waters were shallow, found abundant food, and survived. . . . Active animals reaching the bottom continued to swim, or learned to crawl after food. The more passive forms adhered to the substratum, became relatively inactive, and began the secretion of skeletons because they were no longer able to get rid of the calcium carbonate. . . . Animals had only commenced to discover the bottom in early Cambrian times." Thus it is probable that the Algonkian oceans were teeming with life when they spread over northern Arizona, but most of the animals, being composed only of soft tissue, left no record. Strange it is that a jelly-fish, one of the most perishable of animals, should have left the only imprint so far discovered. Many fossils doubtless are present in the great mass of sediments deposited in the Grand Canyon region, but so widely scattered are they that great masses of rock may be examined without finding any. Search in the Algonkian Apache beds of southern Arizona, probably correlative with the Unkar strata at Grand Canyon, so far has not yielded any animal fossils.

[4] J. Barrell, *Jour. Geol.*, 14: 553–560, 1906.
[5] W. K. Brooks, *Jour. Geol.*, 2: 455–479, 1894.
[6] P. E. Raymond, *Bull. Geol. Soc. America*, 46: 375–391, 1935.

In the lower Unkar and especially in the Chuar group, are many limestones which exhibit the structures commonly described as of algal origin. Some of these probably are inorganic, but many of them seem without question to represent algal secretions. The number of such horizons indicates that, at various times at least, the seas were heavily populated with these primitive plants. Most of the limestones probably are marine, but there is the possibility that some may have been accumulated in fresh-water lakes existing on the flood-plains when the land was above sea level. A detailed study of the considerable variety of these structures in the Grand Canyon Algonkian would be a material contribution to pre-Cambrian paleontology. There is no record of any higher types of plants.

Another indication of the abundance of life during Chuar (later Algonkian) time is the great volume of carbonaceous shale and the smaller quantity of carbonaceous and bituminous limestone. Examination of much of this material which I collected has not yielded any actual fossils. Some of the limestones are so strongly bituminous as to emit a very distinct fetid odor when broken.

NORMAN E. A. HINDS
UNIVERSITY OF CALIFORNIA

A RAINBOW AT NIGHT

I WOULD hesitate to record so trifling an observation as I recently made, were it not for the fact that none of my scientific friends with whom I have spoken seem to be aware of the phenomenon. On the night of June 16, 1938, I observed a rainbow caused by the moon, then only three or four days beyond its full stage. I was crossing from Nassau to Miami on the *Ena-K*, a small motor launch, and was obliged to remain on deck all night. The moon rose about 9 o'clock out of a beautiful calm sea. There was no land in sight. Tumultuous trade wind clouds towered to gigantic heights and there were occasional squalls of rain. About 11 o'clock, when the moon was well up in the southeast sky, the rainbow appeared in the northwest, where a thunderstorm was in progress. The prismatic colors were fairly distinguishable. The arc was complete, the two ends dipping into the sea. At no time was there the least doubt as to the cause of the phenomenon. The conditions were unusually favorable, but probably no more so than at every occurrence of full moon in the trade wind belt, where thunder squalls are common. June is their so-called rainy season for this reason.

A. K. LOBECK
COLUMBIA UNIVERSITY

A NEW LOCALITY FOR THE VENUS' FLY-TRAP (DIONAEA MUSCIPULA)

MR. JOHN BOYD, of Southern Pines, N. C., has been so kind as to send me a number of leaves of the Venus' fly-trap (*Dionaea muscipula*) from a locality in the southeastern corner of Moore County, central North Carolina, a station some distance from any previously recorded. Mr. Boyd writes that the traps range in color from maroon to pink and green. The fringes about the edge are maroon, pink or green. The plants are found growing in open beds, apparently having crowded out all other vegetation.

According to Dr. W. C. Coker,[1] this plant has a range more extensive than is generally assumed. He gives stations in Wayne, Lenoir, Jones, Duplin, Onslow, Sampson, Cumberland, Moore, Bladen, Pender, Columbus, New Hanover and Brunswick Counties, North Carolina, and in north and southeast Horry County and eastern Georgetown County, South Carolina. In other words, it ranges from New Bern, North Carolina, to Murrell's Inlet, South Carolina, and westward to Wayne County and two localities in Moore County, North Carolina. It is, however, very local, and the stations at which it occurs are often widely separated.

AUSTIN H. CLARK

U. S. NATIONAL MUSEUM

[1] *Jour. Elisha Mitchell Sci. Soc.*, Vol. 43, Nos. 3 and 4, July, 1928, pp. 221–228, map, pl. 33.

SCIENTIFIC BOOKS

TRAY AGRICULTURE

Soilless Growth of Plants: Use of Nutrient Solutions, Water, Sand, Cinder, etc. By CARLETON ELLIS and MILLER W. SWANEY. 155 pp., with 59 figures, including 3 color photographs. Reinhold Publishing Corporation, N. Y., 1938. Price, $2.75.

THE National Resources Committee, appointed by President Roosevelt, in reporting last year on the impact of science and invention upon our social and economic life, picked "tray agriculture" as one of the new developments fraught with great future potentialities. This book is welcome because it gives a practical summary of the authors' experience in this promising field, as well as some information selected from the rather scanty literature and experimental bulletins.

It has long been known that some plants, *e.g.*, bulbs which contain their own nutriment, can grow without soil. The well-known hyacinth vases did not enter Omar's mind when he wrote that "every hyacinth the garden wears dropped in her lap from some once lovely head"; but hyacinths, "Chinese lilies" and other plants have been raised in water or on wet pebbles by the hopelessly mid-Victorian housewife. By adding to the water small percentages of potassium, calcium, magnesium, phosphate and nitrate and very minute amounts of the so-called "trace elements," boron, manganese and zinc, we have what the authors term "nutrient solutions," for which a number of detailed formulae are given. By substituting for the flower vases shallow tanks, troughs or trays which may, if one prefers, be filled with sand, pebbles, cinders, etc., and arranging suitable apparatus for continuous or intermittent circulation and aeration of "nutrient solution," we have, according to size, a household or an industrial "plant" for raising plants without soil—by aquaculture, water-culture, tray agriculture, tank farming or (as suggested by W. F. Gericke in SCIENCE, 85: 177, 1937) hydroponics.[1]

Following a brief Foreword and Introduction, Chapter I discusses the chemistry of plant life; Chapter II, growth in mineral aggregates (sand culture and sub-irrigation methods); Chapter III, growth in nutrient solutions (which are here discussed); Chapter IV, household plant culture (flowers and vegetables); Chapter V, commercial aspects, with some striking photographs of large installations and their results, as well as reference to tanks adaptable to automobile trailers and to ocean-going vessels on long voyages; Chapter VI, special chemicals, including plant "hormones," auxins, colchicine[2] (for chromosome doubling), ethylene, ethylene chlorhydrin (*e.g.*, to shorten the dormancy period in potatoes), thiourea (to improve germination), heavy water; Chapter VII, common detriments, including soil diseases, chemical deficiencies, parasites ("animal, vegetable and bacterial"); Chapter VIII, eight nutrient formulas, with comments.

In the Introduction the authors state that they present "a concise and non-technical discussion of the chemistry of plant life and a review of the three recognized modifications of ***soilless growth***, namely, ***water-culture, sand-culture*** and ***sub-irrigation systems***. Numerous household experiments have been included, liberally supplemented by photographs, which may serve to enable the reader to carry on soilless growth experiments at home for the purpose of producing

[1] Professor Gericke (University of California) credits Knop (1859) for early experiments in this field and states: "In the late summer of 1935 a number of large growers of certain vegetables and flowers adopted liquid culture media on a large scale for the growing of crops and have (for two seasons) placed on the market products so grown to compete with those produced by agriculture."

[2] The extreme care necessary in handling this highly toxic alkaloid has been recently stressed, and should be referred to here.

vegetables and flowers for the family. . . . Accounts are given of a number of large-scale soilless-growth operations. . . . Finally, the authors have attempted to repudiate some of the widely circulated, but erroneous, claims made for soilless-growth practices. The reader is warned that plants grown without soil need attention just as do those grown in soil."

With a book intended for popular use, extreme care in the choice of terms must be exercised in order that what is written be scientifically accurate as well as simply stated. In courting simplicity, the authors have been led into some statements that will make scientific readers wince. For example, in speaking (p. 12) of "innumerable tiny pores on the under side of the foliage" they say: "On the proper functioning of these infinitesimal stomata and the microscopic cells within the leaves the entire life of the earth is dependent. For without proper breathing of the stomata the production of the entire food supply of all plants and animals would cease." (How about the evolutionary precursors of plants with foliage? And the authors quote the work of the N. J. Agricultural Experiment Station (New Brunswick, N. J.) where Dr. Selman Waksman has done so much work on the autotrophic bacteria). Page 15: "*Cells?* What are they? . . . They differ in size among plants, but are all formed in more or less the same way, and all serve the same purpose." (The differentiation of cells should at least have been mentioned.) Page 21: "In soil farming the purpose of plowing is to break the soil's upper crust and allow better circulation of air among the roots to take place." (Agriculturists recognize many other benefits, *e.g.*, plowing under of nutrient salts which migrate upward as noted on page 94.) Page 36: An important factor in the accumulation of solar heat in glass-covered containers is the penetration of the glass by the short-length incoming radiation and the impounding of the re-radiated longer heat waves which can not so readily pass out, although "cooling by evaporation of water," mentioned by the authors, is also to be reckoned with. Page 54: In discussing pH, a distinction ought to be made between the *total* acidity or alkalinity of a substance, and the *mobilized* acidity or alkalinity represented by the hydrogen ion concentration. The pH of human blood oscillates about 7.45, and even a few tenths of a unit may mean illness or death. Page 140: Algae are not fungi, nor do they arise from fungi. (Among the parasites, no mention is made of viruses or mosaics.)

All told, however, the authors have presented an interesting and useful résumé in an important new field. They are to be congratulated on the warning they give against high-pressure salesmen who try to sell equipment for this work under promise of miraculous results. They caution against excessive optimism or impatient pessimism. Experimenters are advised to construct their own containers and to use relatively inexpensive commercial grades of chemicals. Under ordinary farming conditions, fertilizing chemicals widely scattered are in part washed away by rain, whereas in hydroponic farming the plants are *protected against rain* so that the nutrient solution is not diluted. The effective utilization of chemicals is higher in tray agriculture, and the onslaught of pests and parasites inhibited or prevented.

It is still to be discovered how soilless growth will affect the quality and viability of seeds thus serially produced; also to what extent the fruits, seeds and plants so grown will carry certain substances (*e.g.*, vitamins, trace elements) needed by animals. From recent work it appears that traces of chromium in forage are essential for sheep and inferentially for other animals too. Possibly impurities in the industrial chemicals will serve to supply such substances, or they may be added. Thus most commercial iron salts contain traces of chromium.

The book is clearly and attractively printed.

JEROME ALEXANDER

SPECIAL ARTICLES

ISOLATION OF A FILTRABLE, TRANSMISSIBLE AGENT WITH "NEUROLYTIC" PROPERTIES FROM TOXOPLASMA-INFECTED TISSUES

A HITHERTO undescribed disease-producing agent, of especial interest because of its unique properties and origin, was encountered in the course of certain experiments with toxoplasma in mice. These toxoplasma (obligate, intracellular, protozoon parasites of large size[1]) have undergone numerous brain to brain passages in mice in the past three years, and repeated tests revealed that no other agent separable by centrifugation or filtration was involved in the disease they produced. After about the fiftieth passage, however, in an attempt to preserve the toxoplasma at −80° C. it was found that while they were invariably killed by this procedure, some other agent capable of producing central nervous system disease in mice either became manifest or was liberated in the process. The disease proved to be transmissible by intracerebral injection and the first strain thus isolated has now undergone more than 30 serial passages. At least six other strains obtained in other toxoplasma experiments by freezing or other procedures have been passaged 4 to 12 times. It has proved impossible, thus far, to isolate or demonstrate this transmissible agent in at least two lines

[1] A. B. Sabin and P. K. Olitsky, SCIENCE, 85: 336, 1937.

of toxoplasma which are being passaged separately in mice.

The transmissible agent, free from toxoplasma, has the following properties:

(1) It does not multiply in ordinary media with or without blood or ascitic fluid, nor in Noguchi's leptospira and bartonella medium, either aerobically or anaerobically.

(2) After intracerebral injection in mice it produces a characteristic turning on the long axis of the body with or without other nervous signs after an incubation period of 1 to 10 days, but usually on the 2nd to 3rd day. Some of the mice die, some continue with choreiform signs for months, but the majority recover in a few days; some of the latter occasionally relapse. The characteristic lesion consists of an acute necrosis and almost complete dissolution of the caudal pole of the cerebellum (this is the reason for temporarily using the term "neurolytic" to characterize this agent); almost equally frequent is a disintegration of the structures around the lateral ventricles. Neither the meylin nor the axis cylinders are spared in the attack and free fat is formed in the process. A variable number of 21- to 30-day-old mice and the majority of those younger than 15 days or older than 2 months show no signs of disease not because they are immune (for the agent multiplies in them and periventricular lesions are present) but because the cerebellum is not involved.

(3) Nasal instillation with or without ether anesthesia, administration by stomach tube, intracutaneous, subcutaneous, intramuscular, intratesticular and intravenous injections of large amounts of active brain suspension have failed not only to produce any apparent disease or recognizable lesions but also to yield any evidence of local or systemic multiplication.

(4) After intraperitoneal or intrathoracic injection of large amounts about 20 to 40 per cent. of the mice develop convulsions and other nervous signs and almost invariably die, most of them 17 to 48 hours after injection, with an occasional one on the third or fourth day. Definite pathological changes were found only in the nervous system (chiefly the neopallial cortex, basal ganglia, cerebellum and nervous part of the retina) where extensive vacuolization and neuronal degeneration were seen. But while the agent has been found in the liver, spleen, kidneys, adrenals and lungs after intraperitoneal and in the lungs after intrathoracic injection, it could not be demonstrated in the brains of these mice (more than 15 experiments), nor in the peripheral blood either before or after the onset of nervous signs. The failure to find an inhibitor and certain other observations suggest that the brain lesions in these mice were not caused by the agent itself but rather by some non-transmissible substance which is formed when it acts on certain types of cells, or by some as yet inconceivable mechanism. After injection into the vitreous of the eye the agent undergoes marked multiplication, but nervous signs were observed in only 1 of 50 mice and that within 16 to 17 hours after inoculation before any appreciable multiplication is apparent.

(5) One intracerebral injection, whether or not it gives rise to clinical signs, renders mice immune to reinoculation by the same route. Their serum, however, contains no neutralizing antibodies; nor were any antibodies found in the blood of normal mice of various ages. Mice which have had one eye almost completely destroyed by the first inoculation are not immune to reinoculation in the other eye.

(6) The neurolytic agent does not so far appear to possess any definite pathogenic properties in rabbits, guinea-pigs, rats and *rhesus* monkeys.

(7) It keeps for months frozen at $-80°$ C. and also after being dried *in vacuo* in the Flosdorff-Mudd apparatus; it remained infective after one month in 50 per cent. buffered glycerol.

(8) An infected mouse brain may contain 1 to 2 million minimal doses, and this amount is not appreciably diminished when a suspension in broth is spun at about 2,000 r.p.m. for 1 hour on a horizontal centrifuge; most of it, however, can be sedimented by spinning for ½ hour at 15,000 r.p.m. on an air-driven angle centrifuge. It could be filtered through Berkefeld V candles and it passed a 720 but not a 628 mμ gradocol membrane suggesting that the size of the smallest particle might be in the range of 314 to 360 mμ. Nevertheless, early attempts to visualize the agent microscopically were unsuccessful. After intraocular injection, however, films of the inner contents of the eye, stained with Giemsa or Wright's stain, constantly revealed peculiar minute structures, staining like the nuclear chromatin, which for the most part appeared in the form of rings or ovals with more intense staining at the poles and occasionally also in the form of larger rings or triangles, quadrangles or still other orientation in which a number of "elementary bodies" appeared to be linked by thinner intervening bonds. These structures were not seen in films stained by Gram's method, safranin, carbol-fuchsin, Ziehl-Neelsen or Abbott's spore stain, or after Cesares-Gil mordanting and counterstaining with carbol-fuchsin or methylene blue. Victoria blue stained them satisfactorily. With Rivers' modification of Castaneda's method staining was poor chiefly because the structures did not appear blue as do Rickettsiae or the elementary bodies of psittacosis, but faintly pink (or purplish depending on the differentiation) like the nuclear chromatin. They could not be visualized in the fresh state in ordinary light, while with the dark-field microscope only the

more unique forms could be discerned with any degree of certainty. The same structures were found free and in association with cells in films of the serous surfaces of the liver, spleen, omentum, lungs and heart of mice succumbing after intraperitoneal inoculation while films prepared in the customary way of the transverse sections of these organs usually revealed nothing. They are difficult to find or identify in brain films.

(9) The neurolytic agent has a lower thermal death point (42–45° C. for 15 minutes) than is known for either pathogenic bacteria or mammalian viruses. Toxoplasma, under similar conditions, were not all killed at 45° C. for one half hour.

Tests with several thousand mice (inoculated with brain, blood or viscera or with normal broth) failed to reveal the presence of the neurolytic agent in the normal stock at the time that it was being isolated from the toxoplasma-infected tissues, nor has it been encountered among thousands of other mice of the same stock used in other experiments in the past three years. Furthermore, the properties of the agent are such that one can not at present conceive how it could possibly be transmitted naturally from mouse to mouse either by itself or through any insect vector. Experiments are still in progress on the possibility of a relationship between the neurolytic agent and toxoplasma, but any ultimate decision on its genesis, if that should ever be possible, must be postponed until further opportunity is given other investigators as well as ourselves to determine whether or not it may occur spontaneously in mice under conditions other than infection with toxoplasma.

Albert B. Sabin

The Rockefeller Institute
for Medical Research
New York, N. Y.

INTERCELLULAR WOUND HORMONES PRODUCED BY HETEROAUXIN

We have published investigations indicating that yeast[1] and animal tissue cells[2] injured by ultra-violet light and other means produce wound hormones which stimulate cellular proliferation. In the case of the wound hormone from yeast, we have been able to show that it probably contains adenine, guanine, pentose, phosphoric acid and possibly nicotinic acid, but not proteins or sulfur, and that it is thus similar to, but not identical with, coenzyme.[3]

Leonian and Lilly[4] concluded from their investigations of the action of heteroauxin on various fungi, algae, etc., that it is a growth inhibitor rather than a growth promoter and that in instances in which it stimulates growth, its action is that of an irritant, leading to the increased production of growth substances by the plant cells.

We have studied the effect of heteroauxin on yeast, using the techniques employed in our wound-hormone experiments.[5] It was found to be toxic throughout a wide range of concentrations, and when yeast was subjected to it in toxic concentrations, wound hormones were produced.

In the toxicity determinations, methylene blue staining was used as a criterion of cell injury. *S. cerevisiae* standing in isotonic salt solutions containing heteroauxin in concentrations from 1:1000 to 1:100,000 showed an increasingly greater percentage of stained cells throughout the period of standing as compared with controls.

In the wound hormone experiments, suspensions of yeast at a concentration of 50 g per L. (wet weight) in isotonic salt solution were divided into two portions, to one of which heteroauxin was added in a concentration of 1:1000. After the suspensions had stood for 24 hours, heteroauxin was added in like concentration to the control suspension, both suspensions were centrifuged and the cell-free supernatant fluids were decanted and taken to dryness. These materials were made up in distilled water to approximately ten times their original concentration in the supernatant fluids, and tested for growth-promoting effect on yeast grown in rocker tubes for 24 hours.[5] The population densities at the end of this period were determined by a photoelectric method.[6] Heteroauxin alone, in the same range of concentrations in which it occurred in the yeast fluids, was added to a portion of the rocker tubes in each experiment.

The tubes to which heteroauxin alone was added showed less growth than controls. Those to which fluid from yeast which had stood with heteroauxin were added showed marked stimulation of growth, while those to which fluid from yeast standing in salt solution only was added showed little or no stimulation, depending upon the concentration of heteroauxin introduced with the fluid.

Separate experiments in which heteroauxin was added to rocker tubes in concentrations from 1:10 to 1:1,000,000 showed depression of growth except for some slight evidence of stimulation in the range near

[1] Fardon, Norris, Loofbourow and Ruddy, *Nature,* 139: 589, 1937; Sperti, Loofbourow and Dwyer, *Studies Inst. Divi Thomae,* 1: 163, 1937; Sperti, Loofbourow and Dwyer, *Nature,* 140: 643, 1937.

[2] Sperti, Loofbourow and Lane, Science, 83: 611, 1937; Loofbourow, Cueto and Lane, in publication.

[3] Cook, Loofbourow and Stimson, Tenth International Congress of Chemistry, Rome, Italy, May, 1938.

[4] Leonian and Lilly, *American Jour. Botany,* 24: 135, 1937.

[5] Loofbourow, Dwyer and Morgan, *Studies Inst. Divi Thomae,* in publication.

[6] Loofbourow and Dwyer, *Studies Inst. Divi Thomae,* in publication.

1:10,000. Since the rocker tube concentrations in the wound-hormone experiments were all above this range, and showed stimulation of a higher order, the stimulation obtained in these experiments can not be accounted for by the direct effect of heteroauxin on the yeast in the rocker tubes.

It is concluded that the effect of heteroauxin on yeast is consistent with the mode of action suggested by Leonian and Lilly for its effect on plant tissues.

JOHN R. LOOFBOUROW
SISTER CECELIA MARIE DWYER, S.C.
INSTITUTUM DIVI THOMAE
INSTITUTE OF SCIENTIFIC RESEARCH
CINCINNATI, OHIO

CHANGES IN WHEAT METABOLISM CAUSED BY POWDERY MILDEW

INFECTION of wheat with the obligate parasite *Erysiphe graminis tritici* results in a gradual decline in vigor and growth, culminating, in cases of severe infection, in the death of the host. This effect of the mildew is accomplished in spite of the fact that the parasite does not penetrate beyond the epidermal cells, in which large-lobed haustoria are formed. Up to the present time it has not been possible to measure separately the respiration and fermentation of an obligate parasite and that of its host. We have been able to accomplish this, however, in the case of *E. graminis tritici*. By carefully scraping away all the wheat tissue except for the lower epidermis, the latter may be obtained as a strip a single cell thick, with the uninjured mildew attached. Measurements on 5 cm.^{2} of normal epidermis give no respiration within the limits of the apparatus ($\pm$ 0.05 c. mm O_2/cm^2 surface per hour), while with a similar area of mildewed epidermis the oxygen consumption is 1.3 c. mm per cm^2 surface per hour. On removal of the mildew from the epidermis with a camel's hair brush the oxygen consumption disappears. Thus the oxygen consumption of mildewed epidermis is, within the limits of experimental error, a measure of the mildew respiration. In this way it is possible to distinguish changes which the mildew induces in the host respiration from gross changes in the host-mildew association.

Our experiments were carried out using a Fenn[1] volumetric micro-respirometer, at 22.0° C. Only the first leaf of normal wheat 15 to 25 days old was used. Within these age limits, respiration and fermentation of wheat are fairly constant. Normal wheat was heavily inoculated about 10 days after planting, and the first leaf used for experimental work 7 to 8 days later. The infected wheat was therefore 17 to 18 days old.

Pratt has shown in an article appearing recently[2] that in wheat inoculated with *Erysiphe graminis tritici* there is a rapid rise in the respiration to a value two to three times that of normal wheat of similar age. We have obtained similar results, as may be seen from the data in Table I. In these experiments the respiration of infected wheat was increased 250 per cent. above that of normal wheat. In addition, we have found that if the mildew is removed from the wheat with a camel's hair brush the respiration does not return to the level of uninfected wheat. This conclusion is borne out by measurements of the respiration of mildewed epidermis. One cm.^{2} of infected epidermis consumes only 1.3 c. mm of O_2 per hour, which is much less than the increase in respiration produced in diseased wheat by the mildew (Table I).

TABLE I

Tissue	c. mm O_2 consumed/cm^2 leaf surface/hour			
	1	2	3	Average
Normal epidermis	±.05	±.05	...	..
Mildewed epidermis	1.17	1.61	1.21	1.3
Infected epidermis Mildew removed	±.05	±.05	...	..
Normal wheat ...	1.81	1.67	1.68	1.7
Mildewed wheat .	6.33	5.22	6.46	6.0
Mildewed wheat .	10.7	6.6	...	..
Mildew removed .	7.4	5.4	...	..

Further confirmation of this conclusion was obtained by the use of sodium azide as a poison to differentiate between the respiration of mildew and wheat. A 0.001 molar solution of sodium azide has no appreciable effect on the respiration of normal wheat, but nearly eliminates the respiration of the mildew (Table II).

TABLE II

Tissue	c. mm O_2 consumed/cm^2/hour				Decrease from control value
	1	2	3	Ave.	
Mildew	1.61	1.08	1.21	1.30	
Mildew NaN_3 ..	.18	.13	...	0.15	
Normal wheat .	1.81	1.68	1.67	1.72*	
Mildewed wheat	6.33	5.34	6.46	6.04	
Mildewed wheat 10^{-3} M NaN_3 .	4.45	3.50	...	4.45	1.39

* In this group of experiments no measurements were made of the respiration of normal wheat in azide. In another set, however, the decrease in azide was only 8 per cent.

If the increased respiration due to infection is largely an increase in host respiration, sodium azide should cause a decrease in the oxygen consumption of mildewed wheat which is not greater than that of the mildewed epidermis. As may be seen from Table II, this is actually the case. Although cyanide is just as effective a poison for the respiration of mildew, it is unsatisfactory as a differential poison, since it stimulates wheat respiration.

The fermentation of normal wheat can readily be compared with that of the infected wheat tissue, as

[1] W. O. Fenn, *Amer. Jour. Physiol.*, 84: 110, 1928.
[2] R. Pratt, SCIENCE, 88: 62, 1938.

mildewed epidermis shows no measurable anaerobic CO_2 production. From Table III it is at once apparent that the infection causes an increase of about 50 per cent. in host fermentation.

TABLE III

Tissue	Anaerobic CO_2 in c. mm			$CO_2/cm^2/hr.$
	1	2	3	Ave.
Normal wheat	1.76	1.80	1.76	1.77
Mildewed wheat ...	2.63	2.70	...	2.67
Mildewed epidermis .	±.03	0.00	±.08	...

The pathogenesis of mildew infection of wheat is correlated with an increase in fermentation and a larger increase in respiration of the host tissue. These changes in the host metabolism occur in the green cells of the mesophyll which are not in contact with, nor invaded by, the hyphae of the mildew. Preliminary measurements of the effect of the disease on photosynthesis indicate that the destruction of functional chlorophyll is subsequent to these changes in fermentation and respiration.

Paul J. Allen
David R. Goddard

Department of Botany,
University of Rochester

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A PRACTICAL BELLOWS RECORDER[1]

The Brodie bellows is regarded as one of the most satisfactory recorders of volume changes that we have. Various modifications have been suggested from time to time, but most of them are time-consuming in preparing them for use or they are too complicated to be easily practical. One of the most popular methods of preparing the Brodie bellows is with cargile membrane. This method presents several difficulties. A set of patterns is necessary to cut the membrane. The gluing constitutes the most troublesome feature of the preparation. It usually requires a skilled technician to prepare one that is effectively air-tight. After one has been used once, it requires continuous attention to insure its being available for a second use, *i.e.*, it must be covered with cotton and soaked in glycerin in order to keep it pliable. A few months' use of this instrument together with frequent failure on the part of technicians to prepare one properly led the author to study the problem with the purpose of devising an instrument that would not lose in accuracy and yet be easy to prepare.

The following device was finally arranged and has been in use for some time by the author and many other workers. It consists essentially of a base plate of brass, to which is attached an arm for mounting to an iron support. At the distal end of the mounting arm is a small removable block which is fastened to the base plate by set screws. Through the middle of the base is drilled a hole, which is countersunk from above. A threaded brass tube with a shoulder at one end passes through this hole, the shoulder fitting accurately into the countersunk depression. The bellows fold is made by using either a rubber condom or, with the smaller models, a thin finger cot. If a condom is used, it may be cut off at about one-half length, and with the removable block raised or removed, the condom is placed on the brass plate until the closed end extends a little beyond the free end of the brass plate. Note the position where the threaded tube which passes through the brass plate lies. Mark the point on the condom and cut a small hole in it at that point. Remove the brass tube and inserting its small end first into the condom, push the small end through the hole previously cut. Place a little colophonium cement in the countersunk depression. Warm it gently and then quickly thrust the tube through the hole and immediately tighten the wing nut screwed on the tube beneath the brass plate. Now place the open end of the condom under the brass block and tighten the set screws. The bottom of this block should be covered with a thin piece of soft leather or blotting paper and a similar piece should be laid on the top of the base plate lying under the block. In our laboratory, we have taken a piece of leather from a lady's kid glove and have split a thin layer from it. The object of the leather is to form a padding to grip the condom tightly when the thumb screws in the block are tightened.

All that is left to do now is to fasten the aluminum plate on the top of the condom. This is done by placing one edge of the aluminum plate in the groove in the brass block. With a spot of colophonium cement on the under side of the plate and with *very gentle* traction on the condom, heat the aluminum plate with a metal rod or small flame and push it down firmly against the rubber, holding it until the cement has set. The object of making slight traction on the condom is to insure the edge of the aluminum plate being drawn back snugly into the groove in the brass block when the condom is released. In this way a perfect hinge is formed and wobbling is prevented. On top of the aluminum plate may be fastened any type of writing point—straw, aluminum or celluloid. The length of the writing point may be suited to the needs of the experiment at hand.

[1] From the Department of Pharmacology, Boston University School of Medicine and the Evans Memorial Hospital.

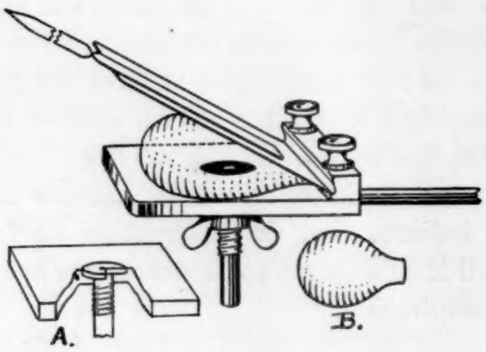

FIG. 1. Bellows recorder.

Fig. 1 is a mechanical drawing of the bellows. Recently we have adopted latex for our balloon material. With this material one can make the balloon any desired shape or size. It is especially desirable to make the balloon smaller in diameter where it passes under the block. Such a shape reduced in size is shown at B in the illustration. At A is a detail drawing of the countersunk depression in the base plate with the brass tube in position. The base plate of the recorder measures 4 cm × 5 cm and is 5 mm thick. It can be made in any shop where tools and a mechanic are available and can be made any desired size. One point indicated in the drawing which might be advantageously changed is the shoulder on the threaded tube which may be made square or, if left round, may be fitted with a tongue which would sink into a corresponding groove in the brass plate. This is to prevent the threaded tube from turning when the wing-nut is tightened, thereby skewing the rubber condom somewhat.

This apparatus has been used in several laboratories, and I have been asked many times to publish a description of it. Dr. Charles Gruber, of Jefferson Medical College, Dr. G. H. Miller, of Iowa City Medical School, and Dr. Fredrick F. Yonkman, of Boston University School of Medicine, have used the bellows and published their results. The bellows was demonstrated at the meeting of the American Society for Experimental Pharmacology and Therapeutics held in Rochester, N. Y., in 1927.

WALTER L. MENDENHALL

"PROPS" FOR COVER GLASSES

A SIMPLE method for "propping up" cover glasses in preparing total mounts of chick embryos, small insects and other specimens requiring raised cover glasses makes use of small bone "curtain rings" which are available in $\frac{1}{2}''$, $\frac{5}{8}''$, $\frac{3}{4}''$ and $\frac{7}{8}''$ diameters, corresponding to standard sizes in round cover glasses.

The bone ring is ground with sandpaper or emery wheel on top and bottom to produce flat adhering surfaces for slide and cover slip. The ground ring is then treated in the same manner as the specimen to be mounted; *i.e.*, washed in distilled water, run through the alcohols, xylol, and impregnated with thin balsam. This procedure is important, especially dehydration, in order that no air or moisture remains in the bony structure to cause "bubbles" or fogging of the balsam after mounting. The rings may be stored in the balsam for later use.

When ready for use, the rings are placed on the slide with sufficient balsam adhering to make a good seal, and then allowed to dry for 24 to 48 hours in a dust-proof cabinet or box. In mounting the specimen, the ring is filled with thick balsam, care being taken to avoid bubbles on the inner and lower periphery of the ring. After placing the specimen in the balsam, more is added until the ring is filled and "heaped" but not overflowing. The cover slip is placed directly over the ring without being pressed down, as the light tension of the cover glass will permit any small bubbles formed to work out and permit some shrinkage of the balsam in drying.

After drying for several days, the ring is "painted" with heavy balsam to form a smooth, even surface finish, and to prevent bubbles of air creeping in as the balsam continues to shrink in drying. An occasional similar application of balsam will make these mounts long-lasting and uniformly neat laboratory slides.

HERTHA M. CORDTS

NEW YORK, N. Y.

BOOKS RECEIVED

BERLAND, L. and F. BERNARD. *Hymenopteres Vespiformes.* Pp. vii + 145. 241 figures. Lechevalier, Paris.

BLUEMEL, C. S. *The Troubled Mind; A Study of Nervous and Mental Diseases.* Pp. ix + 520. Williams and Wilkins. $3.50.

DEBEER, G. R., Editor. *Evolution; Essays on Aspects of Evolutionary Biology Presented to Professor E. S. Goodrich on His Seventieth Birthday.* Pp. viii + 350. Illustrated. Oxford University Press. $5.00.

FRY, WALTER and JOHN R. WHITE. *Big Trees.* Revised edition. Pp. xvi + 126. Illustrated. Stanford University Press. $1.50.

HAAS, ARTHUR E. and IRA M. FREEMAN. *Elementary Survey of Physics; A Non-Mathematical Presentation with a Special Supplement for Pre-Medical Students.* Pp. x + 203. Dutton. $1.90.

HOHAGEN, JORGE. *Boletin del Cuerpo de Ingenieros de Minas del Peru, No. 120; Las Exportaciones Mineras en el Perú, 1937.* Pp. xvii + 396. Imprenta Americana, Lima.

Les Classiques de la Découverte Scientifique: Détermination des Poids Moléculaires; Mémoires de MM. Avogadro, Ampere, and others. Pp. xvi + 165. 7 figures. *La Dissolution; Mémoires de MM. Lavoisier, Gay-Lussac,* and others. Pp. xvi + 148. 7 figures. *Halogènes et Composés Oxygénés du Chlore; Mémoires de Scheele, Berthollet,* and others. Pp. xiv + 147. Illustrated. *Les Métaux Légers; Aluminum, Glucinium, Magnesium, Metaux Alcalins; Mémoires de MM. Henri Sainte-Claire Deville, Héroult,* and others. Pp. xviii + 166. Illustrated. Gauthier-Villars, Éditeur, Paris. 21 fr. each.

Report on the Agricultural Experiment Stations, 1937, U. S. Department of Agriculture. Pp. 226. Superintendent of Documents, Washington. $0.25.